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TRANSACTIONS
of
THE NEW YORK ACADEMY OF SCIENCES

Ser. II, Vol. 1 JANUARY, 1939 No. 3

SECTION OF GEOLOGY AND MINERALOGY

DECEMBER 5, 1938

DOCTOR WALLACE W. ATWOOD, President, Clark University: *The Late Physical History of the Rocky Mountains in the United States.* (This lecture was illustrated by lantern slides.)

The major structural features of the Rocky Mountains are due to the great physical revolution which closed the Mesozoic and opened the Cenozoic eras in that part of the world. In the Rocky Mountain area the early Eocene landscape must have included a number of domes and of anticlinal arches that were rising slowly above the general level of an ancient sea bottom.

As mountain growth continued stream erosion became more and more vigorous. The uplifted rock masses were carved into bold relief features and among the summits of the higher ranges alpine glaciers formed. Before the close of the Eocene period certain broad erosion surfaces were produced and the lower lands bordering the mountain ranges were built up by the deposition of sediments that came from the higher lands. During the Eocene period there had been some vulcanism, and with the renewal of mountain growth near the close of Eocene time vulcanism became very conspicuous at many localities.

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Associate Editor: Eunice Thomas Miner, Executive Secretary.

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There then followed a long mid-Tertiary period of erosion and basin filling, during which the one widespread notable peneplain surface of the Rocky Mountain region was developed. The remnants of that surface are here referred to as parts of the Rocky Mountain Peneplain. The geologic clock had moved on to late Tertiary time. Much of the landscape was subdued; picturesque remnants of the mountain ranges still rose above the great peneplain as monadnocks; there were vast expanses of old age erosion topography and still more extensive waste-filled basins. Much of the mountain structure in the ranges and between the ranges was buried beneath the alluvial filling which had accumulated as the mountains were being worn away.

The long period of stability when the Rocky Mountain Peneplain was developed was brought to a close by a widespread epirogenic uplift. Streams were rejuvenated and a new cycle of erosion was inaugurated. During this period many of the major streams found themselves superimposed upon buried mountain ranges, and as they lowered their courses the great gorges, water gaps, and gateways that add much of scenic attractiveness to the Rocky Mountains were excavated. At this time the Black Canyon of the Gunnison, the gorges of the North Platte and the Laramie were cut. The canyons of the Green River and of the Wind River were excavated. The Royal Gorge of the Arkansas, the Canyons of the Big Horn, and a score of other notches were carved through uplifted mountain masses.

The cycle of erosion during which streams were uncovering the buried ranges and cutting many canyons and gorges was interrupted by a formation of Pleistocene ice. At least three stages of glaciation are recorded during Pleistocene time in these mountains. Since the disappearance of most of that ice the streams have renewed their work of uncovering mountain ranges and of deepening their valleys.

All of the major events that have punctuated the late physical history of the Rocky Mountain region are expressed in one

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way or another in each of the ranges, and must be recorded in a complementary way in the sediments of the basin-like areas among the mountains and in the Great Plains province to the east.

SECTION OF BIOLOGY

DECEMBER 12, 1938

DOCTOR RAYMOND C. PARKER, Rockefeller Institute for Medical Research: *Some Recent Advances in Tissue Culture.* (This lecture was illustrated by lantern slides and motion pictures.) No abstract was received.

REPORT OF THE ANNUAL MEETING

DECEMBER 14, 1938

The 120th Annual Meeting of the Academy for the election of Officers and Fellows, the presentation of reports and the transaction of other business was held at The Hotel Astor on the evening of Wednesday, December 14th.

The Corresponding Secretary reported that there are now upon the rolls of the Academy 44 Honorary Members and 7 Corresponding Members. Two deaths were reported during the past year.

The Recording Secretary reported that, during the year 1938, the Academy held 7 Business Meetings, 1 Round Table Conference, and 26 Sectional Meetings, at which 31 stated papers were presented. Besides the regular Annual Dinner, one General Meeting was held in conjunction with the New York Mineralogical Club and The American Museum of Natural History, at which approximately 1,000 persons were present. The newly formed Section of Physics and Chemistry held a two-day Conference on the subject of "Electrophoresis," which marked a new step in the progressive activities of the Academy, and was not only successful, but was enthusiastically received by the research workers in this highly specialized field. Four smokers were held under the auspices of the various Sections of the Academy with a gratifying attendance at each.

The Executive Committee wishes to acknowledge the cooperation of the Works Progress Administration in furnishing the services of two secretarial assistants to the Academy office.

One Life Member, 3 Sustaining Members, 86 Active Members, 4 Student Members and 116 Associate Members were added to the rolls. Thus a total of 210 new members were added during the year.

The membership of the Academy is at present 747, which includes 2 Patrons, 93 Life Members, 78 Annual Sustaining

Members, 299 Annual Active Members, 80 Student Members, 143 Associate Members, 44 Honorary Members and 7 Corresponding Members; of these 192 are Fellows.

The Academy has lost by death 1 Patron, 3 Life Members, 10 Active Members, 1 Associate Member and 2 Honorary Members.

The Editor reported that four parts of the Annals have appeared, completing Volume 37, and that another part, completing Volume 38, was in press and undoubtedly would be ready for distribution before the end of the calendar year.

Volume VIII, Part 3, of The Scientific Survey of Porto Rico and the Virgin Islands, will also be printed before January 1, 1939. Two additional parts of the Scientific Survey have been edited, which will be ready for distribution before May 1, 1939.

Beginning with the October meetings of this year, the Academy has re-ëstablished the printing of its TRANSACTIONS, and Series II, Volume 1, No. 1, has been sent to all Members of the Academy, and to its exchanges. In this Series will be printed abstracts of papers presented at Academy meetings, as well as Academy notices of importance to Members.

The Librarian reported that 619 separate parts of the Annals have been distributed to the membership list and authors gratis. Twelve hundred separate parts, as well as one complete set of TRANSACTIONS, Series I; Proceedings; and, Annals of the Lyceum and Academy have been sold during the past year to non-members and authors.

During the year 1938, by authority of the Council, 127 parts of The Scientific Survey of Porto Rico and the Virgin Islands were sent to Members, upon payment of their dues. In addition, 120 parts were sold although no new publications in this series appeared this year.

The Library of the Academy sent out 1,585 copies of the Annals to its exchange institutions, and has received in turn 2,328 publications.

An inventory is being made of all publications in stock and will be completed during the coming year.

The Treasurer reported that the surplus for the fiscal year ending November 30, 1937, was $11,425.47. During the past year ending November 30, 1938, receipts from all sources amounted to $14,896.18, making a total with the amount transferred above of $26,321.45. The disbursments for the past year amounted to $11,559.65, leaving a surplus as of November 30, 1938, amounting to $14,762.00.

The A. Cressy Morrison Prizes of $200 each for the two most acceptable technical papers in a field of Science covered by the Academy or an Affiliated Society were awarded to the following papers entitled:

"The Morphology and Functional Evolution of the Atlas-Axis Complex from Fish to Mammals," by F. Gaynor Evans, University of New Hampshire.

"Oxygen Regulates the Dormancy of the Potato," by Norwood C. Thornton, Boyce Thompson Institute for Plant Research.

The A. Cressy Morrison Prize of $500 for the best paper on the origin of solar and stellar energy was awarded to the paper entitled:

"Energy Production in Stars," by Hans A. Bethe, Cornell University.

The following members were elected to Fellowship:

Anne Anastasi, Ph.D.
R. Earl Bowen, A.M., Ph.D.
Charles M. Breder, Jr., D.Sc.
Clarence C. Clark, M.S., Ph.D.
Charles Montague Cooke, Jr., Ph.D.
Frank Co Tui, M.D.
Lawrence K. Frank, A.B.
William Bayard Heroy, Ph.B.
Joseph C. Hinsey, M.S., Ph.D.
James W. Jobling, M.D.
Florence de L. Lowther, A.M., Ph.D.
Duncan MacInnes, M.S., Ph.D.
Alfred Plaut, M.D.
Raymond W. Root, A.M., Ph.D.

S. James Shand, Ph.D., Sc.D.
Luther C. Snider, A.M., Ph.D.
Harold E. Vokes, Ph.D.
Caroline Zachry, A.M., Ph.D.

Honorary Membership was conferred upon three eminent scientists, namely:

Edwin Grant Conklin, A.M., Ph.D., Sc.D., LL.D.
Ross Granville Harrison, A.M., Ph.D., M.D., Sc.D.
Irving Langmuir, Sc.D., Ph.D., LL.D., D.E.

The following officers were elected:—

President

A. Cressy Morrison

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Robert T. Rock, Jr. — Harry L. Shapiro
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Herbert F. Schwarz — John D. Sherman, Jr.
Wayne M. Faunce

After the Business Meeting, the following program was presented:

"The Velocity of Chemical Reactions"
by
Victor K. LaMer

"On the Bottom of a South Sea Pearl Lagoon"
by
Roy Waldo Miner

The abstracts of these papers are included in this issue of the TRANSACTIONS.

NEW YORK ACADEMY OF SCIENCES

Address given at Annual Dinner and Meeting

December 14, 1938

Professor Victor K. LaMer, Columbia University: *The Velocity of Chemical Reactions.* (This lecture was illustrated by lantern slides.)

In the development of the Science of Chemistry, chemists first concerned themselves with the identification and discussion of the various specimens of matter. These inquiries led to the discovery and classification of the chemical elements. The use of the balance yielded data which led to the quantitative laws of chemical combination which later resulted in the introduction of chemical formulae as a shorthand method of designating and describing the properties of matter. The molecular architecture implied in these structural formulae hastened the development of synthetic chemistry. We are indebted to the synthetic practical chemist for producing at low cost, from the raw materials, coal, tar, coke, and petroleum, a myriad of valuable compounds which find abundant use as medicinals, dyes, perfumes, photographic materials, artificial resins and solvents. Although these synthetic products often exist as natural products, many of them have no counterpart in Nature and therefore represent a truly creative development.

The problems of identification, description, purification, and synthesis, have, until the last few decades, been the principal occupation of chemists. Lately, there has been an increasing interest in extending the theoretical aspects of the Science to answer the questions of how and why chemical reaction proceeded. It is this phase of the subject which is the special province of the physical chemist, of whose work I wish to speak tonight.

The greatest single triumph of physical chemistry has been the development of methods for calculating and predicting the

equilibrium state of chemical process. By this term I imply the prediction of the yield in a chemical reaction. These predictions are made by investigating the energy relations for the reaction. This field of inquiry is designated by the erudite term, thermodynamics, and involves the laws governing the conversion of heat into work and chemical equilibrium.

All of the important principles of thermodynamics are embodied in three laws which have been fully established within the last decade. There remains only the problem of working out the details of the applications to special cases. Knowing the heat exchange involved in the reaction, thermodynamics teaches us to calculate precisely the change in yield from the reaction when the temperature and pressure are varied. In order to calculate an absolute value of the yield, thermodynamics requires one value for the yield at some one temperature and pressure. Even this restriction can be removed today by the aid of the third law, if the heat capacities of all the components have been measured to sufficiently low temperatures.

Within the last decade, another special field known as statistical mechanics has developed so that it is now possible to calculate the equilibrium state of a reaction at any temperature and pressure without requiring any measurement to be made upon the reaction in question. Such an "a priori" calculation is indeed an important advance. It is only necessary to know the energy levels of the molecules involved. This information on energy levels is obtained by the spectroscopist from the band spectra of the component substances, and while the exact calculations are still restricted to the gaseous state, new data and methods are accumulating so rapidly that it is possible to make a fairly satisfactory "a priori" prediction in the liquid state. It is by means of such calculations, that my colleague, Professor Urey, first became convinced that it should be possible to isolate the isotopes of hydrogen, nitrogen and carbon. These preliminary calculations have been of inestimable value in guiding the experimental researches to success.

The predictions of thermodynamics unfortunately neglect one important feature, namely, the time factor. Thermodynamics is not competent to state how long a time will be consumed in reaching the equilibrium state. It does the chemical manufacturer very little good to tell him that the process he proposes to use will give him a 99 per cent yield, but that, unfortunately, it will probably take 1,000 years to achieve that high yield.

Chemical kinetics, on the other hand, deals specifically with the problem of hastening the velocity of chemical reactions. It is therefore of the utmost importance to the theoretical and practical chemist.

Thermodynamics has been called legislative in character, while kinetics is executive in character. To borrow from the language of the stock broker, thermodynamics tells exactly what will happen when, as, and if issued, but says nothing at all about how long it will take before the stock will be issued. Perhaps the SEC will not permit the stock to be issued. Observe if by executive action, one can speed up the rate of a chemical reaction, the interest charges upon the investment for equipment in a plant are increasingly reduced.

What do we know about chemical kinetics? Well, compared with thermodynamics, it is still darkest Africa.

If $A + B \rightarrow P$ represents the kinetic reaction between the molecules A and B to form the product P, then we know that if we double the concentration of A; *i.e.*, double the number of molecules of A per unit of volume, the rate is doubled because the number of collisions is doubled, and similarly for the B molecules. Hence doubling the concentration of A and B produces a fourfold increase in rate.

The chemist can therefore modify the rate within limits by controlling the concentration. But what about the absolute rate at unit concentration? Why are some reactions rapid and others slow? In the first place, not every collision between A and B results in reaction. If it did, every gas reaction would proceed with explosive violence since the number of collisions

per second is a prodigiously large number. Only the very exceptional molecules, designated henceforth by the symbol "X" will react. The special characteristic of these X or activated molecules is that the molecules in this critical state of reactivity possess more energy than do those in the normal or nonreactive state.

If every binary collision were fruitful, the rate of reaction would increase only about 4 per cent for every ten degree rise in temperature for that is the rate of increase in number of collisions with the temperature. As a matter of fact, van't Hoff found that the rate of most reactions increases about 300 to 400 per cent over a ten degree interval but in an exponential manner.

The molecules in a gas move with different velocities. The majority move at a velocity very nearly equal to the statistical average velocity. The temperature of the gas is simply another way of expressing this average velocity. Only a very few molecules move with a velocity much greater than the average. When two molecules of average velocity collide, they bounce apart and nothing further happens. When two very rapidly moving molecules collide, the extra energy of translation disrupts them. They exchange partners and, instead of dancing, a reaction occurs. The energy of activation arises then from the translational energy involved in the collisions of very fast or hot molecules.

According to Maxwell and Boltzmann, the chance that a molecule will have an exceptionally high velocity is exponentially related to its translatory energy E. The law for the temperature dependence of the rate of a reaction, consequently, has the same form. In fact we find that

$$\text{rate} = Ze^{-E_{act}/RT}$$

is a formula which often works remarkably well in gases in spite of its mathematical simplicity. Z is the number of collisions.

Today physical chemists are representing the energy relations between different molecules and their reaction products

by energy diagrams which resemble the contour maps of a mountainous country. The number of interchanges in the population of people living in the valleys separated by a mountain pass is determined by the number of people in the community, the height and character of the roads leading over the mountain pass, and the mountain climbing ability of the natives. The modern concept of reaction kinetics is well portrayed by this geographical and ethnological illustration.

The higher the mountain pass, which is the same thing as saying that the molecules require a large energy of activation to react, the fewer the interchanges. The more roads that are constructed over the mountain pass, the more easily it can be traversed. Until recently, theory has neglected the possibility of more than one road over the mountain pass. The entropy of activation is the term which expresses this factor. Its importance is being recognized as result of intensive work by the author at Columbia University and by Professor Eyring at Princeton University.

It does not require any great stretch of the imagination to recognize that a sharpshooter, with a machine gun, stationed at the top of the mountain pass, can effectively prevent many climbers from traversing the pass. This concept underlies the secret of the explanation for negative catalysis. While it is very important to be able to speed up chemical reactions in order to reduce the capital outlay for plant equipment, it is equally important to inhibit the deteriorating chemical processes which destroy valuable products. One of the most fascinating recent developments has been that of negative catalysis.

My own researches at the present time deal with the problem of determining the effect of electric charges upon the molecules through their effect upon the energy of activation and the entropy of activation.

If we know the rate at which $A^0 + B^0 \rightarrow P$, how rapidly will $A^+ + B^-$ or $A^- + B^-$ react? It requires only an elementary knowledge of electrostatics to recognize that the reaction between ions of the same sign will be slower because the electrical re-

pulsive forces will prevent collisions. This is found to be the case; on the other hand, if we make the molecules of opposite electric charge, a very marked increase in rate occurs because of the greater number of collisions. A^+ and B^- will, on the average, be closer together than will A^0 and B^0. Quantitatively we find the influence on the rate is in exact accord with electrostatics. It depends upon the square of the electric charge, and inversely upon the square of the radii of the molecules and inversely as the dielectric constant, just as Coulomb's law predicts.

If we change the solvent we change the rate of reaction, and in the case of ionic reactions by an enormous amount. The action is primarily through the dielectric constant. If we pass from water to alcohol, a reaction of the type $A^+ + B^-$ is speeded up because the electric fields are greater in the lower dielectric medium, alcohol, than in the higher dielectric medium water. On the other hand, a reaction of the type $A^- + B^-$ or $A^+ + B^+$ is slowed down on adding alcohol as would be expected.

It has been known for a long time that the addition of salt markedly reduces or increases the rates of ionic reactions. If the reaction is of the type $A^+ + B^+$, salt additions increase the rate. If of the type $A^+ + B^-$, salt additions decrease the rate. This is due to the fact that the numbers of collisions are affected by the electric charges of all the ions in the solution. This last effect is known as Primary Salt Catalysis. For many years Salt Catalysis remained an enigma of physical chemistry, but today we can confidently predict its magnitude. These researches represent one of the first definite examples of how a Catalyst works.

NEW YORK ACADEMY OF SCIENCES

Address given at Annual Dinner and Meeting

DECEMBER 14, 1938

DOCTOR ROY WALDO MINER, American Museum of Natural History: *On the Bottom of a South Sea Pearl Lagoon.* (This lecture was illustrated by colored lantern slides and motion pictures.)

The Island of Tongareva (also known as Penrhyn Island) is a coral atoll situated in the South Pacific 9° S. and 158° 2′ W. It is 1847 miles south of Honolulu, and almost on the same meridian, the longitude of that port being only 30′ farther west. The islets of which it is composed, called *motus* by the natives, surround a central lagoon about eleven miles in diameter. They are connected by coral reefs awash at low tide, except at three entrances, one at the north-east; one at the north-west; and a third on the western border of the atoll. Only the latter can be navigated by vessels of larger size.

The island is low-lying, being nowhere more than 50 feet above sea-level, and is covered with luxuriant growths of coconut trees. It is inhabited by about 500 indigenous Polynesians gathered in two settlements, Omoko and Tetautua, on the east and west shores of the atoll respectively. The lagoon varies in depth, from 15 to more than 200 feet. It is floored with sand and mud but many coral shoals rise from the bottom, often reaching within a foot or so of the surface. Many others occur in process of upward growth. The shoals are particularly numerous in the western part of the lagoon. Pearl-shell occurs abundantly over about a quarter of the lagoon bottom, and the waters are alive with gaily colored fishes.

The natives live on various dishes made from coconut and on the fish and edible mollusks captured in and about the atoll. The chief exported products are copra and pearl-shell. Trading schooners enter the lagoon and tie up at the wharf of

Omoka about twice a month to load with copra and pearl shell, as well as palm fibre hats, mats, and various other articles woven by the native women.

On September 18, 1936, an expedition from the American Museum of Natural History arrived off the West Passage of Tongareva led by the writer in cooperation with Mr. Templeton Crocker of San Francisco, who accompanied the expedition to put the services of his yacht *Zaca* and its crew of 17 men at the disposal of the party. Also from the Museum were Wyllys R. Betts, field associate; Chris Olsen, artist and modeler; and Wiliam F. Coultas, ornithologist. The latter was on his way to Samoa and other Pacific Islands to secure birds for museum groups. Mr. Betts, Mr. Olsen, and I had come to Tongareva to study the pearl oyster beds of the island and the methods by which the natives secured the pearl shell. Thus we could obtain material and accurate data from which a Pearl Fisheries Group could be constructed for the Hall of Ocean Life in the American Museum. In this work, we also received invaluable aid from Mr. Crocker's staff, particularly, Toshio Asaeda, Japanese artist and photographer, and Frank Tiaga, a native Samoan sailor. Mr. Philip Woonton, British Government Agent at Tongareva, gave us special facilities and put at our disposal Tau, a native diver, to act as guide and pilot.

We were fortunate in having two weeks of continuously favorable weather for our purposes. Our vessel had been guided into the lagoon through the narrow and hazardous West Passage by native pilots and was brought to anchor off the village of Omoko, the picturesque huts of which snuggled under the towering groves of coconut palms. The first three days were spent exploring the lagoon with a launch under the guidance of Mr. Woonton and Tau. After we had selected the locations best adapted for our work, we loaded our cameras, undersea boxes, and film in an otter boat equipped with a motor, while the diving outfit consisting of two helmets, two pumps, undersea tripods, brass-rope ladder, and hose were packed into a dory, which was taken in tow. The dory also

carried water glasses, nets, and various fishing appliances. Two sailors from the *Zaca* manned the otter-boat together with Tau and Toshio, the Japanese artist. Betts, Olsen, and I, with Frank, the Samoan, occupied the dory. When we arrived alongside one of the table-like shoals, the dory was secured fore and aft by carrying two anchors out and hooking them on to the top of the spreading corals. The otter boat was lashed parallel to the dory on the outer side, and the brass-rope ladder was lowered from the inner side. Though the shoal-top lay close to the surface, its sides descended precipitously to a depth of twenty-five feet or more. After examining the bottom with a water-glass, I stood on the rope ladder with the water washing my shoulders while the diving-helmet was lowered over my head and a pump was started going. The rungs of the ladder, constructed of brass piping, were placed a foot apart, so that, by counting them as I descended, I could measure my depth as I stepped off at the bottom. I could then see the cliff-like sides of the coral shoal rising above me, luxuriantly overgrown with corals of many species, ranging through every imaginable tint of color, while in form they varied from massive dome-like growths to branching clusters of the utmost delicacy and lace-like fragility. In one particular gorge, afterward chosen for the scene to be reproduced in the proposed Museum group, I recognised various species of *Siderastraea, Porites, Galaxea, Pocillopora, Turbinaria, Fungia, Leptoseris, Podabacia, Merulina* and many others, while the genus *Acropora* was present in overwhelming abundance, ranging from arbusculate to paniculate growths.

Along the sea-floor here and elsewhere occurred patches of pearl-oysters (*Avicula margaritifera*) from a few individuals to numerous clusters. For the most part, they dotted the sea-bottom here and there, either lying flat on the sand, or growing in clusters of two or three on the dead coral rock. The valves were about eight inches in diameter. When alive, the edges of the shells were usually slightly parted, with flat finger-like projections extending from the margin representing the

radiating lines of growth between which the shelly material filled in as it grew outward. The outside of the shell of the living oyster was usually overgrown with calcareous algæ, bryozoa, and encrusting sponges, of various contrasting colors.

A smaller species of pearl shell, called by the natives the *pipi* shell, also occurs. Associated with the corals and pearl shell in the neighborhood of the shoals is the smaller *Tridacna* (*T. compressa*). This occurs partially embedded in the coral rock or in the sand, and sometimes growing loosely on coral clumps. It is about a foot in length and is a miniature of the great *Tridacna gigas,* its near relative, characteristic of the Philippines, the Carolines, and the Great Barrier Reef. There is no space here to mention the many species of echinoderms, annulates, crabs, shrimp, and other forms of life comprising the remainder of the reef association, but hosts of these were observed, recorded, and collected. The reef fishes were particularly abundant and varied. Their vivid colors and often grotesque forms were conspicuous as we stood on the sea-floor.

We had two diving helmets and pumps, so that either Betts or Olsen were working undersea with me most of the time. Our tripods were lowered to us on a cord and placed in position. Then the cameras encased in specially contrived undersea boxes were lowered, and photographic records by motion pictures and stills were made in waters so transparent that there was no difficulty in photographing 25 feet below the surface.

Tau, the Tongarevan diver, and his companion, Tony, would dive down and wrest clusters of shell from the sea-bottom, while we photographed them in the act. Chris Olsen carried palette and oil colors undersea and made oil sketches from life on oiled canvas stretched over plate glass. Many specimens were brought up alive and placed in aquaria on the *Zaca* that detailed color studies might be made of them. We caught the brilliant reef fishes by hook and line and in fish-traps. Others that could not be secured in any other way were

stunned by using the "bang-bang," a bamboo pole, to the end of which dynamite caps were attached, connected by an insulated electric wire with a switch box in the dory. We would stalk fishes over the sea bottom, using diving helmets, and holding the "bang-bang" out like a fish-pole until the caps were over the fish in question, when we would jerk the cord as a signal, the sailor in the dory would close the switch, and the caps would explode, stupefying the fish. Tau would then dive down with a hand-net, scoop up the fish, swim to the surface and turn over his catch to Toshio, who would place it in a pail of sea water. After a time the fish would recover and Toshio would make accurate sketches of it in color. The fishes thus captured were brought back to the *Zaca* and plaster molds were made of them, while the original specimens were preserved in fluid.

By these various methods, we not only made first hand observations and records of the reef association in which the pearl oyster occurs, but secured an abundance of specimens. The collections included more than 10 tons of coral, hundreds of pearl shell, and large series of other invertebrates.

The Pearl Divers Group is now being constructed at the American Museum and, when completed, will be a trustworthy record of the ecological conditions under which the pearl shell is found in a typical island of the South Pacific.

SECTION OF ANTHROPOLOGY

DECEMBER 28, 1938

DOCTOR GEORGE C. VAILLANT, American Museum of Natural History: *The Documentation of the Archaeology of the Valley of Mexico.* (This address was illustrated by lantern slides.)

The techniques for amassing information have so governed American archaeology in the last twenty years, that the vast bulk of data on time and tribe acquired in that period is seldom intelligible to the non-professional reader. For most of the New World there are no native historical records so that knowledge of the Indians' past must largely depend on such material culture remains which have resisted the destructive action of time and weather. Therefore, any place or culture which has a documentation is extremely important in American archaeology and the Valley of Mexico is preeminent in this respect in that it is the source of more historical manuscripts than any of the past of Indian America. Furthermore, the archaeological sequences in this region are very well known.

There are four main stages to the development of human history in Central Mexico. The latest is the Aztec period, which is preceded by a phase of immigration involving various types and stages of culture. This we call the Chichimec period and it supersedes a third period of unified culture, known as the Teotihuacan or Toltec. The fourth and earliest epoch in the Valley reveals people with a fair technical development, but without the ceremonial expression found in the later periods. This Early Culture of Archaic phase is by no means primitive and archaeology has not yet revealed these steps found elsewhere in the Americas whereby man levered himself from a hunting and food gathering role to that of a sedentary farmer.

Most of our records come from the Aztec period and are either picture writings or else commentaries based on similar

documents which have been lost. Most of the manuscripts refer to the histories of individual city states, tribute rolls, genealogies, maps, etc., which produce much additional information. A curious feature of this documentary evidence is that much of it was composed in the half century following the Spanish Conquest and many older pictographic records seem to have been copied at this time. Therefore the net effect is to have in addition to an analysis of Indian civilization in Mexico prior to the Conquest, an interesting picture of the persistence of Indian culture in Early Spanish Colonial times.

The city states of the Valley of Mexico were usually founded by groups of immigrants during the Chichimec period. In a number of cases notably Tenochtitlan (the ancient Mexico City) and Texcoco, the local annals describe and picture this period of migration and early settlement. Other records compiled from picture records, but set forth in European script, utilizing in some cases the Spanish language and others Nahuatl, provide further information on Chichimec times. In this fashion some four centuries of history can be reviewed, supplementing and being supplemented by the archaeological record.

The Teotihuacan period, historically speaking, is poorly covered. Our source material is traditional and was passed on by scribes and annalists in Chichimec and Aztec times. Yet even here the archaeological record is implemented by these ancient memories and in turn the techniques of excavation have provided data which render authentic these ancient tales.

As a result vividly and accurately one can discern the evolution of culture, and how various culture traits were transmitted. Trade and the payment of tribute undoubtedly influenced material culture, but in addition there is mention of groups of people breaking away from a parent community to join a new one, a condition sometimes arising from overpopulation and sometimes from political dissensions within the community. Tributary groups in some cases absorbed various traits from their conquerors, and the reverse condition is

also true. The idea of emulation seemed also strongly to operate, and there are several examples of the spread of the idea of chiefly lineage, which resulted in the gradual disappearance of the earlier and more primitive group council rule. The state of ferment in Central Mexico in the centuries preceding the Conquest is clearly brought out in the chronicles, and the parallel to European conditions is very apparent, a cultural unity spreading and developing in the face of the most violent political dissension.

There is a rich field awaiting a historically inclined ethnologist in the Central Mexican field, where so much data, unrecoverable by direct archaeological techniques, are here preserved. The study of acculturation problems could also profitably be extended to the post-Conquest era, and the student of modern Mexican ethnology would find much to guide him under these almost laboratory conditions. Much of the material exists in print, thanks to the labors of the nineteenth century scholars, but the great advances in sociology and ethnology warrant a general re-examination of the published data.